I hereby certify that this correspondence is being deposited with the United States Postal Service as Express Mail Label Number ER 287728152 US in an envelope addressed to: Mail Stop - Patent Application - Commissioner for Patents - P.O. Box 1450 - Alexandria, VA 22313-1450

January 9, 2004

Date

Eric R. Benson, Esq.

DESCRIPTION

Personal Cooling and Heating System

BACKGROUND ART

There are no acceptable prior art heat stress and cold weather exposure relief systems for individuals, such as soldiers, operating in hot and cold environments for extended periods of time. Desert conditions for example often place individuals in a heat stress environment during the daylight hours and in severe cold during the nighttime. Heat stress can result in sweating, fatigue, dehydration, dizziness, hot skin temperature, muscle weakness, increased heart rate, heat rash, fainting, injuries, weight loss, heat stroke, heat exhaustion, and even death. The risk of heat stress is even greater for those wearing nuclear, biological and chemical (NBC) protective clothing, as well as aircrew personnel wearing flight gear. Cold weather exposure can cause discomfort; pain; numbness; cardiac, circulatory and respiratory problems; diminished muscle function and performance; frostbite, and hypothermia which can lead to unconsciousness and death.

While a portable, lightweight, low power, personal cooling and heating system can reduce heat stress, reduce the adverse effects of cold exposure, improve performance, and reduce water consumption, current active and passive cooling systems fall short of meeting the minimum requirements for an optimal system.

Active personal cooling devices are well know in the prior art. Also active personal heating systems are known in the prior art. The prior art, however, seems to be devoid of a combination cooling and heating system functioning with any significant efficiency over longer periods of time. The current active cooling and heating systems, however, are too heavy, bulky, inefficient, and are effective for only a limited amount of time. These devices also consume too much power and use potentially dangerous materials such as lithium sulfur dioxide batteries or R134 a refrigerant. Passive cooling and heating systems use packets containing phase change chemicals, water or gel that require refrigeration, freezing or heating before use are not suitable to meet the needs of a user where refrigeration, freezing or heating of the

passive cooling or heating components are unavailable such as in military field operations in hot, cold or combined hot and cold climatic conditions. The prior art active cooling and heating systems that have been developed, include:

1. U.S. Army PICS (Personal Ice-Cooling System) **Problem**: This system uses packed ice. The ice must be changed every 30 minutes, and users such as pilots and field deployed soldiers may not have access to ice to replenish the system.
2. U.S. Army PVCS (Portable Vapor Compression Cooling System) **Problems:** The total system is much too heavy (27 pounds); uses potentially dangerous lithium sulphur dioxide batteries, can't use vapor compression on non-level surfaces such as ships; R134a containers can rupture in high temperatures, exposure to liquid or vapor refrigerant can cause frostbite, high exposure to fumes can cause central nervous system depression, irregular heartbeat and suffocation.
3. U.S. Army ALMCs (Advanced Lightweight Microclimate Cooling System) **Problems:** A voltage delay phenomenon can cause lithium sulphur dioxide batteries not to start especially after storage; the batteries can vent toxic sulphur dioxide gas that can cause respiratory distress and burns if there is accidental electrical charging, puncturing or application of heat. The batteries are not rechargeable, cannot be exposed to high temperatures, are very reactive with water and cannot be opened, punctured or crushed.
4. IMCC (Integrated Mesoscopic Cooling Circuits) (DARPA) **Problem**: Insufficient cooling.
5. Absorption/ Evaporative Cooling (DARPA). **Problem:** According to Roger Masadi at the Natick Soldier Center, typical desiccants only adsorb about 20 percent of their weight in water, and the cooling density is approximately the same as ice.
6. NASA and U.S. Air Force (APECS) Aircrew Personal Environmental Control System **Problem:** This system is too bulky for infantry soldiers.
7. Life Enhancement Technologies **Problem:** The ice water mixture for the cooling unit must be replenished.

While each of these prior art personal cooling and heating systems may fulfill their respective particular objectives and requirements, and are most likely quite functional for their intended purposes, it will be noticed that none of the prior art cited disclose an apparatus and/or method that is portable, rugged, and lightweight and that can be used in any orientation or used as a belt-mounted system or a backpack, to meet

the operational requirements of the user. Also, the prior art cannot provide several continuous hours of operation at a rate of 700 to 1000 BTUs of adjustable cooling or heating per hour.

As such, there apparently still exists the need for new and improved personal cooling and heating system to maximize the benefits to the user and minimize the risks of injury from its use.

In this respect, the present invention disclosed herein substantially corrects these problems and fulfills the need for such a device.

DISCLOSURE OF THE INVENTION

In view of the foregoing limitations inherent in the known types of personal cooling and heating systems now present in the prior art, the present invention provides an apparatus that has been designed to provide the following features for a user:

- Minimum of 700 to 1000 BTUs of adjustable heating or cooling per hour.
- Maximum system weight of 8 pounds including vest, coolant and battery power source.
- Minimum of two hours of continuous operation.
- On-demand cooling and heating.
- 2000 failure-free hours.
- Self-powered.
- Resistant to chemical agents.
- Easily decontaminated.
- Easy to maintain with a minimum of hand tools.
- Safe to the touch.
- Power supply compatibility with other flight line or aircraft systems.
- Compliance with electromagnetic compatibility and interface (EMC/EMI) requirements.
- The system can be operated and recharged by ground power cart or aircraft power.

These features are improvements which are patently distinct over similar devices and methods which may already be patented or commercially available. As such, the general purpose of the present invention, which will be described subsequently in greater detail, is to provide a field designed apparatus and method of use that incorporates the present invention. There are many additional novel features directed to solving problems not addressed in the prior art.

To attain this the present invention generally comprises four main components: 1) the Cooling Unit **(CU)**; 2) the Heating Unit **(HU)**; 3) the Power Supply **(PS)**; and

4) the Vest.

An additional object and advantage of the present invention is that unlike the prior art personal cooling and heating systems the present invention provides a fully user adjustable cooling and heating system that combines efficient cooling and heating in one device maximizing user comfort. The controls are easy to use and the unit is durable for use in the field, including military operations.

These together with other objects of the invention, along with the various features of novelty which characterize the invention, will be pointed out with particularity in the claims. For a better understanding of the invention, its operating advantages and the specific objects attained by its uses, reference should be had to the accompanying drawings and descriptive matter in which there is illustrated preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the personal cooling and heating unit of the invention.

FIG. 2 is a perspective view of the belt mounted personal cooling and heating unit and vest of the invention as worn by a user on a belt.

FIG. 3 is a graphical analysis of the Thermoelectric Cooler **(TEC)** Module depicted in **FIG. 4 and FIG. 5**.

FIG. 4 is a perspective view of the Circulating Pump, the Liquid Heat Exchanger, the Thermoelectric Cooler **(TEC)** Modules, and the Air Heat Exchanger.

FIG. 5 is an exploded perspective view of the personal cooling and heating unit of the embodiment depicted in **FIG. 1 and FIG. 2**.

FIG. 6 is a flow sheet depicting the elements and functioning of the Evaporative Cooling Vest embodiment.

FIG. 7 is a flow sheet depicting the elements and functioning of the Chemical/Biological Protective Suit Evaporative Cooling Vest embodiment.

FIG. 8 is a flow sheet depicting the elements and functioning of the personal cooling and heating unit and vest of the invention generally depicted in **FIGS. 1,2 and 5**.

FIG. 9 is a flow sheet depicting the elements and functioning of the cooling fin embodiment of the personal cooling and heating unit and vest of the invention.

FIG. 10 is a flow sheet depicting the elements and functioning of the vest mounted heat exchanger embodiment of the personal cooling and heating unit and vest

of the invention.

BEST MODES FOR CARRYING OUT THE INVENTION

A. PREFERRED EMBODIMENTS

With reference now to the drawings, and in particular to Figures 1-10 thereof, a new and novel apparatus for a personal cooling and heating system **(PCHS)** embodying the principles and concepts of the present invention is depicted in these drawings as comprising two major components, the Vest and the Personal Cooling and Heating Unit **(PCHU)** and are generally designated by the reference numerals **21** and **22** respectively.

General Description of Reference Numerals in the Description and Drawings

Any actual dimensions listed are those of the preferred embodiment. Actual dimensions or exact hardware details and means may vary in a final product or most preferred embodiment and should be considered means for so as not to narrow the claims of the patent.

List and Description of component parts of the invention:

(1) Reversible Thermoelectric Cooler **(TEC)** Modules.
(2) Liquid Heat Exchanger Frame
(2A) Vest Loop Liquid Heat Exchanger
(2B) Cooling Loop Liquid Heat Exchanger
(2C) Condenser Loop Liquid Heat Exchanger
(3) Temperature Sensor
(4) Hot Side Silicon Sealing Gasket
(5) Cold Side Silicon Sealing Gasket
(6) Hot Side Liquid Heat Exchanger Back Plate
(7) Cold Side Liquid Heat Exchanger and Heater Transfer Plate Back Plate
(8) Electric Heating Strip
(9) Heat Reflector and Insulator Pad
(10) Insulating and Cushioning Pad
(11) Air Heat Exchanger
(12) Air Heat Exchanger Discharge End Cap
(13) Brushless Fan Motor
(14) Air Heat Exchanger Fan End Cap
(15) Fan Impeller Housing
(16) Air Heat Exchanger Fan
(16A) Air Heat Exchanger Fan Impeller
(16B) Cooling Fin Fan
(17) Fan Housing Cap

- **(18)** Wiring, Plumbing and Controller Enclosure
- **(19)** Micro Controller, Display and Keypad
- **(20)** Battery Power Supply
- **(21)** Vest
- **(22)** Personal Cooling and Heating Unit **(PCHU)**
- **(23)** Cooling Loop Pump
- **(23A)** Condenser Fluid Pump and Fluid Sensor
- **(23B)** Vest Loop Pump
- **(24)** Temperature Selector
- **(25)** Quick Release Hose and Fittings
- **(26)** Air Heat Exchanger Cooling Liquid Channel
- **(27)** Air Heat Exchanger Air Channel
- **(28)** Vest Air Cooler and Condenser
- **(29)** Vest Air Fan
- **(30)** Protective Suit
- **(31)** Cooling Fin
- **(32)** Liquid Pack
- **(33)** Condensed Liquid Drain Pump
- **(34)** Vest Air Channel
- **(35)** Vest Exhaust Duct
- **(36)** Vest Intake Duct
- **(37)** Condensing Coil

I. Detailed Description of the Most Preferred Embodiment:

- The user clips the Personal Cooling and Heating Unit **(PCHU) (22)** and the Battery Power Supply **(20)** onto a belt and plugs the Quick Release Hose and Fittings **(25)** from the Vest **(21)** into the Personal Cooling and Heating Unit **(PCHU) (22)** as depicted in **Fig 2**.
- Cooling or heating is started by activating the power switch of the Micro Controller, Display and Keypad **(19)** on the Personal Cooling and Heating Unit **(PCHU) (22)** as depicted in **Figs. 1 and 5**. The user can adjust the cooling or heating rate by a wireless or wired remote control.
- For cooling, the Micro Controller, Display and Keypad **(19)** checks the capacity of the Battery Power Supply **(20)** and begins to monitor the system's Temperature Sensors **(3)**. While monitoring the Temperature Sensors **(3)**, the Micro Controller, Display and Keypad **(19)** automatically makes adjustments to the speed of the Air Heat Exchanger **(11)** Air Heat Exchanger Fan **(16)**, the flow rate of the Cooling Loop Pump **(23)** and the temperature of the Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** to meet the user's

cooling and/or heating requirements with the most power-efficient settings.

- The Micro Controller, Display and Keypad **(19)** powers up the Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** and continually monitors the power supply drain and capacity. The Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** provide cooling or heating (per the user's selection) by changing the temperature of the liquid flowing through the Vest **(21)**.
- The Vest Loop Pumps **(23B)** circulate a water-based cooling liquid through the Vest **(21)** and Vest Loop Liquid Heat Exchanger **(2A)** and the Cooling Loop Pumps **(23)** in a separate isolated loop pump cooling liquid through the Air Heat Exchangers **(11)** until the user selected cooling is achieved.
- The Air Heat Exchangers' **(11)** Air Heat Exchanger Fans **(16)** are powered up as required to provide heat transfer from the Air Heat Exchanger **(11)** to the ambient air.
- For heating, a flexible Electric Heating Strip **(8)** is attached to the Vest Loop Liquid Heat Exchanger **(2A)** by means of the Cold Side Silicon Sealing Gasket **(5)** and the Cold Side Liquid Heat Exchanger and Heater Transfer Plate Back Plate **(7)**. The flexible Electric Heating Strip **(8)** heats liquid in the Vest Loop Heat Exchanger **(2A)** and the Vest Loop Pump **(23B)** circulates the heated liquid through the Quick Release Hose and Fittings **(25)** to and through the Vest **(21)**.
- The Battery Power Supply **(20)** can be exchanged or recharged after two or more hours of operation depending upon user settings and concomitant energy demands.

<u>Description of Components of The Personal Cooling and Heating System of the Most Preferred Embodiment</u>

The Personal Cooling and Heating System has four main components:

1) Cooling Unit (CU):

In the Preferred Embodiment as depicted in **Figures 1,4,5,6,7,8 and 10** the Cooling Unit (CU) is comprised of nine Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** attached to a Liquid Heat Exchanger Frame **(2)** to form a Vest Loop Liquid Heat Exchanger **(2A)** such that the cold side of the nine Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** form the side of the Vest Loop Liquid Heat Exchanger **(2A)** and the nine Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** are also attached to a Liquid Heat Exchanger Frame **(2)** to form a Cooling Loop Liquid

Heat Exchanger **(2B)** such that the hot side of the nine Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** form the side of the Cooling Loop Liquid Heat Exchanger **(2A)**; two Cooling Loop Pumps **(23)** capable of pumping a cooling fluid from the Cooling Loop Liquid Heat Exchanger **(2B)** to two Air Heat Exchangers **(11)**; the two Air Heat Exchangers **(11)** each having attached its own Air Heat Exchanger Fans **(16)**, each of which Air Heat Exchanger Fans **(16)** is comprised of an Air Heat Exchanger Fan Impeller **(16A)** a Brushless Fan Motor **(13)** which are housed in a Fan Impeller Housing **(15)**, an Air Heat Exchanger Fan End Cap **(14)** and a Fan Housing Cap **(17)**; a Micro Controller, Display and Keypad **(19)** electrically and/or electronically connected to: 17 internal Temperature Sensors **(3)** in the Vest **(21)**; the two Air Heat Exchanger Fans **(16)**; the Cooling Loop Liquid Heat Exchanger **(2B)**; and the two Cooling Loop Pumps **(23)**.

2) Heating Unit (HU):

In the Preferred Embodiment as depicted in **Figures 5,8 and 9** the Heating Unit uses the following components of the Cooling Unit: the Vest Loop Liquid Heat Exchanger **(2A)** which is attached to a flexible Electric Heating Strip **(8)**; one Vest Loop Pump **(23B)**, and the Micro Controller, Display and Keypad **(19)** electrically and/or electronically connected to: 17 internal Temperature Sensors **(3)** in the Vest **(21)**; the Vest Loop Pump **(23B)**. The flexible Electric Heating Strip **(8)** heats the Vest Loop Liquid Heat Exchanger **(2A)** and the Vest Loop Pump **(23B)** circulates the heated liquid up through the Vest **(21)**. The flexible Electric Heating Strip **(8)** will evenly distribute heat over the Vest Loop Liquid Heat Exchanger **(23B)** to provide the optimal heat transfer to the user.

3) Power Supply (PS) (20):

In the Preferred Embodiment as depicted in **Figures 1,5,6,7,8,9 and 10** the Battery Power Supply **(20)** for both the Cooling and Heating Units are generally off-the-shelf, rechargeable Lithium Ion batteries for Phase I. The Cooling Unit Power Supply will weigh four pounds and the Heating Unit Power Supply will weigh an additional 3 pounds to heat 700 BTU for 2 full hours. The system design will determine whether the batteries packs are mounted on the main unit or as separate packs.

4) Vest (21):

In the Preferred Embodiment as depicted in **Figures 2,6,7,8, 9 and 10** the system will be used with a Vest **(21)** containing a tubing or channel through which a

cooling/heating liquid can flow. The Vest **(21)** is fitted with Quick Release Hose and Fittings **(25)** to allow the user to remove the Cooling Unit and Heating Unit without taking off the vest **(21)**. The weight of the Vest **(21)**, including the liquid and couplings is approximately two pounds. The Cooling Unit circulates a water-based heat exchange liquid through tubing within the Vest **(21)**. Liquid warmed by the user's body exits the Vest **(21)** by being pumped into the Vest Loop Liquid Heat Exchanger **(2A)** by the Vest Loop Pump **(23B)**. Channels within the Liquid Heat Exchanger Frame **(2)** conduct the warmed liquid such that it comes in contact with the nine Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** thus transferring the heat from the liquid to the cold side of the nine Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** that form the side of the Vest Loop Liquid Heat Exchanger **(2A)**. The heat is transferred from the liquid directly to the cold sides of the nine Reversible Thermoelectric Cooler **(TEC)** Modules **(1)**. Peletier junctions within the nine Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** transfer the heat from the cold sides of the Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** to the hot sides of the Reversible Thermoelectric Cooler **(TEC)** Modules **(1)**. Heat from the hot sides of the Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** is transferred to the Cooling Loop Liquid Heat Exchanger **(2B)**. The Cooling Loop Liquid Heat Exchanger **(2B)** transfers the heat to the cooling liquid as it circulates through the Cooling Loop Liquid Heat Exchanger **(2B)**. Air Heat Exchangers **(11)** are located on either side of the Cooling Loop Liquid Heat Exchanger **(2B)**. The cooling liquid carries the heat to the two Air Heat Exchangers **(11)** and transfers the heat to the Air Heat Exchanger **(11)** as it circulates through the Air Heat Exchanger Cooling Liquid Channel **(26)**. An Air Heat Exchanger Fan **(16)** located on the top of each of the Air Heat Exchangers **(11)** blows ambient air through the Air Heat Exchanger Air Channel **(27)** providing forced convection cooling of the Air Heat Exchanger **(11)**. The heat is transferred to the ambient air and exits out of the bottom of the Air Heat Exchanger **(11)**. The cold sides of the Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** maintain the liquid in the Vest **(21)** at the cooling temperature desired by the user as set by the user on the Micro Controller, Display and Keypad **(19)**.

The individual components of the device as depicted in the drawings are comprised and function as follows:

1. Reversible Thermoelectric Cooler (TEC) Modules (1)

Reversible Thermoelectric Cooler **(TEC)** Modules **(1)**, also known as Pelitier devices, are small devices that act as heat pumps. The Reversible Thermoelectric

Cooler **(TEC)** Modules **(1)** are usually composed of small Bismuth Telluride cubes sandwiched between two ceramic plates. When a DC current is applied to the module, heat is moved from one side of the TEC module Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** to the other. To create greater efficiencies and reduce the size and weight of the Personal Cooling and Heating Unit **(PCHU)** **(22)**, when the Micro Controller, Display and Keypad **(19)** activates the Cooling Unit the cold side of the nine Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** forms the side of the Vest Loop Liquid Heat Exchanger **(2A)** and the hot side of the same nine Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** forms the side of the Cooling Loop Liquid Heat Exchanger **(2B).** For maximum efficiency the Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** are activated by a reversible direct current that is pulsed from the Micro Controller, Display and Keypad **(19)**, the power for which is supplied by the Battery Power Supply **(20)**.

2. Vest Loop Liquid Heat Exchanger (2A) and Cooling Loop Liquid Heat Exchanger (2B)

In the Preferred Embodiment the Vest Loop Liquid Heat Exchanger **(2A)** and Cooling Loop Liquid Heat Exchanger **(2B)** are each comprised of a Liquid Heat Exchanger Frame **(2)** and nine Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** forming the sides of the Cooling Loop Liquid Heat Exchanger **(2B)** and the Vest Loop Liquid Heat Exchanger **(2A)**. For cooling, warmed liquid exiting the Vest **(21)** is circulated through the Vest Loop Liquid Heat Exchanger **(2A)** and cooled by coming in direct contact with the cold side of the nine Reversible Thermoelectric Cooler **(TEC)** Modules **(1)**. For heating, cool liquid exiting the Vest **(21)** is circulated through the Vest Loop Liquid Heat Exchanger **(2A)** and heated by coming in direct contact with the hot side of the nine Reversible Thermoelectric Cooler **(TEC)** Modules **(1)**. The Liquid Heat Exchanger Frame **(2)** will be initially fabricated out of plastic, but may be constructed of any suitable material. The Liquid Heat Exchanger Frame **(2)** may be divided into two separate channels from which the two Cooling Loop Pumps **(23)** draw and ultimately return the cooling liquid the respective separate channels. This design provides a more effective heat transfer rate from the liquid to the Liquid Heat Exchanger **(2)**.

3. Vest Loop Pump (23B) and Cooling Loop Pumps (23)

A Vest Loop Pump **(23)** circulates liquid through the Vest Loop Liquid Heat Exchanger **(2A)** and the Vest **(21)** in one closed circuit and in another closed circuit

the Cooling Loop Pump **(23)** circulates liquid through the Cooling Loop Liquid Heat Exchanger **(2B)** and the Air Heat Exchanger Cooling Liquid Channels **(26)** in the two Air Heat Exchangers **(11)**. The Vest Loop Pump **(23B)** and the Cooling Loop Pumps **(23)** are designed to have two gears as depicted in **Figure 4**. A variable speed, brushless DC motor will power one gear that drives the other gear, providing precise management of the circulation of the cooling/heating liquid.

4. Air Heat Exchanger (11)

The Air Heat Exchangers **(11)** are attached opposite sides of the Personal Cooling and Heating Unit **(PCHU) (22)** containing the nine Reversible Thermoelectric Cooler **(TEC)** Modules **(1)**, the Vest Loop Liquid Heat Exchanger **(2A)** and the Cooling Loop Liquid Heat Exchanger **(2B)**. Each Air Heat Exchanger **(11)** is cylinder-shaped and has formed within it are several Air Heat Exchanger Cooling Liquid Channels **(26)** and several Air Heat Exchanger Air Channels **(27)**. The Air Heat Exchanger Cooling Liquid Channels **(26)** are comprised of a series of round holes around the perimeter of the top of the Air Heat Exchangers **(11)** that run vertically to the bottom of the Air Heat Exchangers **(11)**. When used as a cooling device the liquid when warmed by the user's body is pumped from the vest through the Vest Loop Liquid Heat Exchanger **(2A)**. As the liquid travels through the Vest Loop Liquid Heat Exchanger **(2A)** it is cooled. The Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** provide cooling to the Vest Loop Liquid Heat Exchanger **(2A)**. The Cooling Loop Liquid Heat Exchanger **(2B)** removes heat from the Reversible Thermoelectric Cooler **(TEC)** Modules **(1)**. The Air Heat Exchangers **(11)** takes the heat from the Cooling Loop Liquid Heat Exchanger **(2B)**. When two Air Heat Exchangers are used, each Air Heat Exchanger **(11)** takes half of the heat from its corresponding side of the Cooling Loop Liquid Heat Exchanger **(2B)** which is comprised of a divided two separate channel Liquid Heat Exchanger **(2)** and the nine Reversible Thermoelectric Cooler **(TEC)** Modules **(1)**. Liquid from one separate channel of the Cooling Loop Liquid Heat Exchanger **(2B)** is pumped by one Cooling Loop Pump **(23)** down through Air Heat Exchanger Cooling Liquid Channels **(26)** of one of the Air Heat Exchanger **(11)** in a closed loop. The liquid travels down the Air Heat Exchanger Cooling Liquid Channels **(26)** through the length of the canister of the Air Heat Exchanger **(11)** and then back up and down around the interior of the canister of the Air Heat Exchanger **(11)**. The liquid then exits out of the bottom of the canister of the Air Heat Exchanger **(11)** and back into the Cooling Loop Liquid Heat Exchanger **(2B)**. Similarly, liquid from the other separate chamber of the Cooling

Loop Liquid Heat Exchanger **(2B)** is pumped by a second Cooling Loop Pump **(23)** down through the opposite Air Heat Exchanger's **(11)** Air Heat Exchanger Cooling Liquid Channels **(26)** located in the top of the opposite Air Heat Exchanger **(11)** in a closed loop. The liquid travels down the the opposite Air Heat Exchanger's **(11)** Air Heat Exchanger Cooling Liquid Channels **(26)** through the length of the canister of the opposite Air Heat Exchanger **(11)** and then back up and down around the interior of the canister of the opposite Air Heat Exchanger **(11)**. The liquid then exits out of the bottom of the canister of the opposite Air Heat Exchanger **(11)** and back into the Cooling Loop Liquid Heat Exchanger **(2B)**.

5. Air Heat Exchanger Fans (16)

The Air Heat Exchanger Fans **(16)** are variable (0 to 180) CFM fans used to provide forced convection cooling through the Air Heat Exchanger Air Channels **(27)** of the Air Heat Exchanger **(11)**. The Air Heat Exchanger Fan **(16)** will be powered by a 16 mm diameter Maxon Brushless Fan Motor **(13)**. In the best mode the Air Heat Exchanger Fans **(16)** will be fabricated out of high-temperature plastic. The Air Heat Exchanger Fans **(16)** and Brushless Fan Motors **(13)** will be installed in the centers of the tops of the Air Heat Exchanger **(11)**.

The Air Heat Exchanger Fans **(16)** push ambient air through holes comprising the Air Heat Exchanger Air Channels **(27)** located on the top and through the Air Heat Exchanger **(11)** canisters. The holes are located inside the perimeter of the round holes comprising the Air Heat Exchanger Cooling Liquid Channels **(26)** and run vertically from the top through the bottom of the Air Heat Exchanger **(11)** canister. The Air Heat Exchanger Fans **(16)** will push air down through the Air Heat Exchangers' **(11)** Air Heat Exchanger Air Channels **(27)** and out the bottom of the Air Heat Exchangers' **(11)** canister, thus creating an efficient airflow and heat removal. While air is flowing through the Air Heat Exchangers **(11)**, heat is being transferred to or from the ambient air.

6. Controller

The Micro Controller, Display and Keypad **(19)** is mounted to the top of the Vest Loop Liquid Heat Exchanger **(2A)** and the Cooling Loop Liquid Heat Exchanger **(2B)**. The Micro Controller, Display and Keypad **(19)** monitors the remaining charge capacity of the Battery Power Supply **(20)** and take measurements from 17 Temperature Sensors **(3)** located: 1) in each of the four tubes connecting the Air Heat Exchanger **(11)** and the Cooling Loop Liquid Heat Exchanger **(2B)**; 2) on the hot and

cold sides of the Reversible Thermoelectric Cooler **(TEC)** Modules **(1)**; 3) in both the Vest Loop Liquid Heat Exchanger **(2A)** and the Cooling Loop Liquid Heat Exchanger **(2B)**; 4) in both Air Heat Exchangers **(11)**; 5) the Vest **(21)** and the inlets and outlets of the liquid for the Vest Loop Liquid Heat Exchanger **(2A)** and the Cooling Loop Liquid Heat Exchanger **(2B)**.

By monitoring these temperatures, the Micro Controller, Display and Keypad **(19)** will select the configuration of power required for optimal cooling and heating. The Micro Controller, Display and Keypad **(19)** will read the required heating or cooling level specified by the user with a Temperature Selector **(24)** and provide that precise amount of cooling or heating. The user will manually set a thermostat to the desired temperature of number of BTUs within the range of 700-1000 BTUs.

The Micro Controller, Display and Keypad **(19)** will control the Cooling Loop Pump **(23)**, the Vest Loop Pump **(23B)**, the Air Heat Exchanger Fans **(16)** and Brushless Fan Motors **(13)**, and the temperatures of the Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** to provide the most efficient cooling and heating of the liquid that flows through the Vest **(21)**.

Heating

The temperature of the liquid must reach a minimum of 100 degrees F and preferably 110 degrees F in order to provide sufficient heating, and the nine Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** are not capable of generating this amount of heat alone. The operational components required during heating would be the nine Reversible Thermoelectric Cooler **(TEC)** Modules **(1)**, the flexible Electric Heating Strip **(8)** or a fuel burner, one Vest Loop Liquid Heat Exchanger **(2A)**, one Vest Loop Pump **(23B)**, the Micro Controller, Display and Keypad **(19)** and the Vest **(21)**. The Cooling Unit would be shut off during heating.

Odorless, clean-burning, non-smoking liquid fuels such as liquid benzine, pure white gasoline or lighter fluid may be used in a fuel burning embodiment as a replacement for the flexible Electric Heating Strip **(8)**. The burner would be installed on the Vest Loop Liquid Heat Exchanger **(2A)** that connects to the Vest **(21)**. The drawbacks of using the burner are that the user would be required to carry a flammable liquid, would have to light the burner to ignite it, and the Vest **(21)** would need to be worn on the outside of the user's other clothing, making it unsuitable for a hazmat protective suit. It would be possible to design a burner with an electronic ignition and controls that would not require the user to manually light it or shut it off. This type of design would provide the most heat for the weight of the system but would potentially

be very dangerous for use in such activities as flight line maintenance since they are typically working in proximity to aircraft fuel vapors.

7. Electric Heating Strip (8)

The flexible Electric Heating Strip **(8)** is an electric heater that is attached to the cold side of the nine Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** comprising a side of the Vest Loop Liquid Heat Exchanger **(2A)** which in turn is functionally connected to the Vest **(21)**. When the user sets the invention for heat to be delivered to the device the flexible Electric Heating Strip **(8)** heats the cold side of the nine Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** comprising the side of the Vest Loop Liquid Heat Exchanger **(2A)** which heat is stepped up or increased by the nine Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** which in turn heats the liquid that is in contact with the hot side of the nine Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** comprising the side of the Vest Loop Liquid Heat Exchanger **(2A)** and then the Vest Loop Pump **(23B)** will circulate the heated liquid up through the Vest **(21)** thus warming a user. The invention may be manufactured such that the area and size of the area of the Vest Loop Liquid Heat Exchanger **(2A)** that will be heated may be changed, allowing precise regulation of the temperature to the Vest **(21)** through thermostatic and electronic control.

8. Battery Power Supply

The Battery Power Supply **(20)** is a battery pack of currently available, rechargeable Lithium Ion batteries that weighs four pounds and supplies 7.2 volts providing at least two hours of continuous operation. The rechargeable battery pack of the Battery Power Supply **(20)** has a one-hour recharging cycle time. Currently available non-rechargeable batteries and disposable fuel cells can provide either less weight or a longer operating time of up to 6.5 hours of continuous operation. For example, Lithium/Manganese Dioxide 3-volt batteries weigh .242 lbs. per cell. For 4 hours of cooling, 10 cells would be used at a total weight of 2.42 lbs. For 6.5 hours of cooling, 16 cells would be used at a total weight of 3.88 lbs. Zinc-Air 5.2 volt fuel cells weigh 1.7 lbs. per cell. For 4 hours of cooling, 14 cells would be used at a total weight of 2.38 lbs. For 6.5 hours of cooling, 22 cells would be used at a total weight of 3.74 lbs. However, neither the Lithium/Manganese Dioxide or fuel cell batteries are rechargeable.

Battery technology keeps on improving and manufacturers of rechargeable batteries, non-rechargeable batteries and fuel cells have publicized that by the end of

2003 they will be offering products that weigh 50 percent less and have two to three times the capacity of their current products which could lead to a 35% reduction in size and weight of this invention.

Figure 3 graphically illustrates a specific configuration of Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** that will provide 125 watts of cooling for 46 watts of input of electrical power. The coefficient of performance for this configuration of Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** is 270 percent.

II. Detailed Description of the Evaporative Cooling Embodiments:

The Evaporative Cooling Embodiments of the current invention are generally depicted in **Figures 6 and 7**. The Cooling Unit of the Most Preferred Embodiment is used in each of the Evaporative Cooling Embodiments with the exception that the Vest Loop Liquid Heat Exchanger **(2A)** is substituted with a Condensor Loop Liquid Heat Exchanger **(2C)** which is divided into two chambers. Two separate Condensor Fluid Pumps **(23A)** draw heated condensor fluid through its own separate Condensing Coil **(37)** located in its own Vest Air Cooler and Condensor **(28)** and pumps the heated condensor fluid into the respective separate chambers of the Condensor Loop Liquid Heat Exchanger **(2C)** such that the heated condensor fluid makes direct contact with the cold side of the nine Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** that form the side of the Condensor Loop Liquid Heat Exchanger **(2C)** thereby cooling the condensor fluid prior to being pumped back through the Condensing Coil **(37)**.

The Vest **(21)** has a series of Vest Air Channels **(34)** contained therein which are attached to two Vest Intake Ducts **(36)** that is located opposite to two Vest Exhaust Ducts **(35)**. A Vest Air Fan **(29)** is attached to each of the two Vest Intake Ducts. When the Temperature Sensors **(3)** indicate the user selected temperature is lower than the temperature in the Vest **(21)**, the Micro Controller, Display and Keypad **(19)** activates the two Vest Air Fans **(29)** drawing the warm air in the Vest Air Channels **(34)** through the Vest Exhaust Ducts **(35)** into the respective Vest Air Cooler and Condensor **(28)** thereby causing the warm air to pass in and around the Condensing Coil **(37)** therein and cooling the warm air as it passes. The cooled air then passes into the respective Vest Intake Duct **(36)** where the cooled air then returns to the Vest Air Channels **(34)** of the Vest **(21)** to remove more heat from the Vest **(21)** thereby cooling the user.

A Condensor Fluid Pump and Fluid Sensor **(23A)** is activated by its sensor when condensate accumulates in either or both of the Vest Air Cooler and Condensers

(28) thereby pumping the accumulated condensate away out of the Vest Air Cooler and Condensor **(28)**.

In the event that the Temperature Sensors **(3)** indicate the user selected temperature is higher than the temperature in the Vest **(21)**, the Micro Controller, Display and Keypad **(19)** shuts off the Cooling Unit and then electrically activates the flexible Electric Heating Strip **(8)** that is attached to the cold side of the nine Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** comprising a side of the Condensor Loop Liquid Heat Exchanger **(2B)** and it activates the two separate Condensor Fluid Pumps **(23A)** which now draw cooled condensor fluid through its own separate Condensing Coil **(37)** located in its own Vest Air Cooler and Condensor **(28)** and pumps the cooled condensor fluid into the respective separate chambers of the Condensor Loop Liquid Heat Exchanger **(2B)** such that the heated condensor fluid makes direct contact with the now hot side of the nine Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** that form a side of the Condensor Loop Liquid Heat Exchanger **(2B)** thereby heating the condensor fluid prior to being pumped back through the Condensing Coil **(37)**. The Micro Controller, Display and Keypad **(19)** simultaneously electrically activates the two Vest Air Fans **(29)** drawing the cool air in the Vest Air Channels **(34)** through the Vest Exhaust Ducts **(35)** into the respective Vest Air Cooler and Condensor **(28)** thereby causing the cold air to pass in and around the now hot Condensing Coils **(37)** therein and thus warming the cold air as it passes. The warmed air then passes into the respective Vest Intake Duct **(36)** where the warmed air then returns to the Vest Air Channels **(34)** of the Vest **(21)** to remove more coldness from the Vest **(21)** thereby warming the user.

The Chemical - Biological HAZMAT Protective Suit **(30)** Embodiment depicted in **Figure 7** incorporates all the features of the above described Evaporative Cooling Emodiments except that the Vest Intake Duct **(36)** is formed by the HAZMAT Protective Suit **(30)**. The HAZMAT Protective Suit **(30)** is worn by a user and contains inside the Protective Suit **(30)** with the user the two Vest Air Cooler and Condensors **(28)**, the two Condensing Coils **(37)**, the two Vest Air Fans **(29)**, the Vest Intake Ducts **(36)** formed by the inside of the Protective Suit **(30)**, the twoVest Exhaust Ducts **(35)**, the Temperature Sensors **(3)** and the Vest **(21)**.

III. Detailed Description of the Air Cooled Cooling Unit Embodiment:

The Air Cooled Cooling Unit Embodiment of the current invention is generally depicted in **Figure 9** and it utilizes all the same components and features of the most

preferred embodiment with the exception that: the Cooling Loop Liquid Heat Exchanger **(2B)**; the two Cooling Loop Pumps **(23)**; and the two Air Heat Exchanger Assemblies **(11,12,13,14,15,16,16A and 17)**; are all replaced with a Cooling Fin **(31)** attached to the hot side of the nine Reversible Thermoelectric Cooler **(TEC)** Modules **(1)** that form a side of the Vest Loop Liquid Heat Exchanger **(2A)** when the Micro Controller, Display and Keypad **(19)** indicates that the Vest **(21)** requires cooling. A Cooling Fin Fan **(16B)** then blows ambient air across the Cooling Fin **(31)** thus cooling the Cooling Fin **(31)** which in turn cools the liquid flowing into the Vest **(21)** thereby cooling the user.

The Heating Unit of the Air Cooled Cooling Unit Embodiment of the current invention is generally depicted in **Figure 9** and it utilizes all the same components and features of the most preferred embodiment without exception.

While my above descriptions of the invention, its parts, and operations contains many specificities, these should not be construed as limitations on the scope of the invention, but rather as exemplifications of present embodiments thereof. Many other variations are possible, for example, other embodiments, shapes, and sizes of the device can be constructed to fit on a user and work with a unit designed to work by the principles of the present invention; various materials, pumps, colors and configurations can be employed in the unit's design that would provide interesting embodiment differences to users including such practical designs as would, for instance conceal the unit.

Accordingly, the scope of the invention should be determined not by the embodiments illustrated, but by the claims and their legal equivalents as filed herewith.

Having described my invention, I claim: